The Targon®-PH Nail, an intramedullary fixator for unstable capital humeral fractures in the elderly patient: a retrospective study of 39 patients

Frölich, Thomas ; Rancan, Mario ; Schwaller, Adrian ; Vollenweider, Andreas ; Mica, Ladislav

Abstract: The proximal humeral fracture occurs very often especially in elderly patients suffering from osteoporosis. Minimally invasive internal fixation with the Targon®-PH proximal humeral nail may lead to quick recovery. Thirty-nine patients with unstable humeral head fractures with two or four fragments were included into this study. The application of the humeral nail was achieved by deltoid split technique. Patients were followed-up clinically and radiologically including a Constant Score. The mean age was 72.9±3.3years of the male and 74.9±1.8years of the female patients. The subjective parameters of the Constant-Murley Score were significantly lowered in both the female and the male sample compared with the healthy side (female 30.0±1.1 vs. 33.7±0.7; $P<0.05$; and male 30.3±1.4 vs. 34.0±0.7; $P<0.05$). The objective parameters were significantly lowered also in both the female and the male sample compared with the non-operated side (female 34.5±2.0 vs. 45.2±1.1; $P<0.001$; and male 37.7±5.4 vs. 50.6±1.7; $P<0.05$). Even under lowered functionality, the subjective satisfaction was high; therefore, nailing of proximal humeral head fractures may represent a method for early functional recovery in elderly patients

DOI: https://doi.org/10.1007/s00590-011-0884-9

Eur J Orthop Surg Traumatol (2012) 22:535–540
DOI 10.1007/s00590-011-0884-9

ORIGINAL ARTICLE

The Targon®-PH Nail, an intramedullary fixator for unstable capital humeral fractures in the elderly patient: a retrospective study of 39 patients

Thomas Frölich · Mario Rancan · Adrian Schwaller · Andreas Vollenweider · Ladislav Mica

Received: 22 September 2011 / Accepted: 5 October 2011 / Published online: 18 October 2011

Abstract The proximal humeral fracture occurs very often especially in elderly patients suffering from osteoporosis. Minimally invasive internal fixation with the Targon®-PH proximal humeral nail may lead to quick recovery. Thirty-nine patients with unstable humeral head fractures with two or four fragments were included into this study. The application of the humeral nail was achieved by deltoid split technique. Patients were followed-up clinically and radiologically including a Constant Score. The mean age was 72.9 ± 3.3 years of the male and 74.9 ± 1.8 years of the female patients. The subjective parameters of the Constant–Murley Score were significantly lowered in both the female and the male sample compared with the healthy side (female 30.0 ± 1.1 vs. 33.7 ± 0.7; $P < 0.05$; and male 30.3 ± 1.4 vs. 34.0 ± 0.7; $P < 0.05$). The objective parameters were significantly lowered also in both the female and the male sample compared with the non-operated side (female 34.5 ± 2.0 vs. 45.2 ± 1.1; $P < 0.001$; and male 37.7 ± 5.4 vs. 50.6 ± 1.7; $P < 0.05$). Even under lowered functionality, the subjective satisfaction was high; therefore, nailing of proximal humeral head fractures may represent a method for early functional recovery in elderly patients.

T. Frölich · A. Schwaller · A. Vollenweider
Clinic of General Surgery, Spital Männedorf,
8708 Männedorf, Switzerland

M. Rancan
Clinic of General Surgery, Stadtspital Triemli,
8063 Zürich, Switzerland

L. Mica (✉)
Department of Trauma Surgery,
University Hospital of Zürich, Rämistrasse 100,
8091 Zürich, Switzerland
e-mail: ladislav.mica@usz.ch

Keywords Targon®-PH nail · Unstable capital humeral fracture · Neer classification · Deltoid split · Elderly patient

Introduction

Fractures of the proximal humerus or humeral head are common in the elderly patient. The overall prevalence of proximal humeral fractures is about 70/100,000 persons in Western Europe [1, 2], this represents about 5% of all fractures in adults. The prime objective is not to restore muscular power in the elderly patient but to allow individual reintegration in daily life without pain. These daily life activities do not need much strength but require a reasonable range of movement in elderly patients. A special point is sufficient rotator stability for washing, combing hair and for personal hygiene.

Pre-existing osteoporosis or osteopenia in elderly patients can lead to highly challenging treatment strategies in common humeral head fractures [3–8]. A conservative treatment of humeral head fractures depends on patient's compliance and the fracture type but does not always promise good results [7, 9]. Treating such fractures by arthroplasty gives good relief from pain, but the outcome in terms of functionality is poor [10, 11] due to the secondary resorption of the humeral tuberosities [12, 13]. The resorption of the tuberosities results in cranial migration of the prosthesis [14] and hence to impaired function of the injured shoulder. Because of these clinically and subjectively not satisfactory results, the primary osteosynthesis has become the standard treatment procedure [15]. Open reduction and internal fixation by plate osteosynthesis renders the fracture fragments to further blood supply deterioration and thus to osteonecrosis compared with a closed reduction and an intramedullary fixation, e.g. by the Targon®-PH nail [16].

A plenty of different techniques have been used to address this problem [17, 18], such as cerclage wires, T-plates, tubular plates and intramedullar nailing techniques [19, 20]. Pre-existing osteopenia and osteoporosis make these fractures challenging to treat, too soft and flexible implants may lead to pseudarthrosis and material failure on one hand, on the other hand too rigid materials may be torn out of the osteoporotic bone [21] during physiotherapeutical treatment. A treatment where the Böhler criteria [22] are fulfilled with a good pain relief should be chosen in the elderly patient to assure good quality of life. However, the best type of osteosynthesis in this type of fracture has not been found yet.

The Targon®-PH nail resembles an angular-stable intramedullary system developed for the treatment of humeral head fractures. It allows a minimally invasive approach to the fracture, an indirect reposition with the osteosynthesis material and it is rigid enough to allow physiotherapeutical treatment even if implanted to osteoporotic bones. The aim of this study was to analyse the outcome of geriatric patients treated with the Targon-PH® nail. In this retrospective study, we present a collective of 39 patients over 70 years old with proximal humeral head fractures treated by intramedulary stabilization with the Targon®-PH nail compared with the non-operated shoulder.

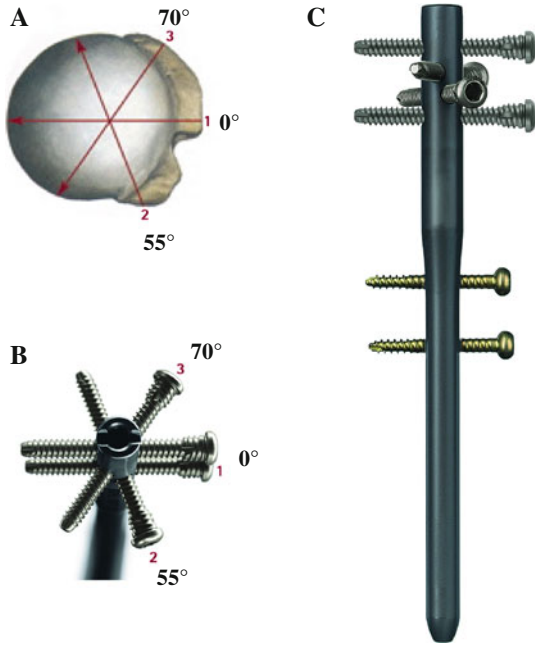

Fig. 1 The Targon®-PH nail. **a** *Top view* of the humeral head. The *arrows* show the optimal position of the head screws in relation to the both tubercula. The crews at 0° should be positioned just next to the intertubercular sulcus. **b** *Top view* of the Targon®-PH nail. Shown is the angulation of the screws in the nail. **c** Side view of the Targon®-PH nail (8 mm/150 mm) with two fixation screws for the humeral shaft. The pictures were kindly provided by B-Braun®, Sempach, Switzerland

Patients and methods

Patient sample

Thirty-nine geriatric patients with an approximate age of 70 years or over with a dislocated two- to four-part humeral head fracture according to the Neer classification [23] or 11-A2 to 11-C2 according o the AO Classification were included into this study. Younger patients or patients with a significantly lower biological age were treated with conventional plate osteosynthesis (data not shown). The decision to treat a fracture with the Targon-PH® nail was made by the operating surgeon with an associated subjective bias.

Osteosynthesis material and surgical approach

The Targon®–PH nail was used for internal stabilization of the humeral head fractures (Targon®-PH nail 8 mm × 150 mm (0.31 inch × 5.91 inch), B-Braun, Sempach, CH). The material was used according to manufacturer's guidelines (Fig. 1). The operative technique has been published previously [24]. Briefly, the patient was placed in beach-chair position on a radiolucent operation table with a loose arm rest. A deltoid split approach was chosen, and the incision was made at the anterolateral margin of the acromion. In displaced fractures, three to four-part, the incision can be kept within a range of 2–4 cm (0.8–1.6 inch). The rotational cuff and articular capsule were incised at the rotational interval in a length of approximately 1.5 cm (0.6 inch). The reduction in the head fragment was achieved with a 2.5-mm (0.1 inch) K-wire in *"joystick"* technique. In displaced four-part fractures, the tubercular fragments were temporarily held in place using 1.2–1.6-mm (0.05–0.06 inch) K-wires. The tendons of the supraspinate muscle and pectoral muscle were secured with Fibre-wire and pulled to the side to achieve anatomical reposition. The nail was then inserted manually with the targeting device. If the entrance point was chosen correctly, the final anatomical reposition was usually achieved by the nail itself. To consider light fracture sintering and to avoid rotatory cuff damage, the nail should be positioned about 5 mm (0.2 inch) below the cartilage surface. Considering the different orientation of the tubercula (Fig. 1), the nail has to be correctly oriented with the targeting device before applying the humeral head screws.

Postoperative treatment and follow-up

Postoperatively, the patients were treated with analgetics according to the VAS (visual analog scale) recommended by the World Health Organization. Physiotherapeutical

exercise was started immediately after the removal of the subacromial drainage. The patients were attended to avoid *forced* active elevation over 90° and *forced* rotation for 6 weeks. Normally, patient's full reintegration was achieved after 3 months depending on the age and patients residual activity.

Final follow-up examination

Radiographs were taken routinely after 6 weeks, after 3 and 6 months and at the last check-up. The Constant–Murley score was used to compare objectively the function of the shoulder and subjectively patient's satisfaction at the last check-up, as described previously [25]. All degrees were measured by a commercially available conventional protractor. The force was measured by a commercially available force metre initially in kilograms (kg) and secondary transformed into pound (lbs) with the converting factor 2.205.

Statistical analysis

Groupwise statistical comparisons were made using the unpaired t test or One-Way Analysis of Variance according to the number of groups. For data that were not normally distributed, the Mann–Whitney rank sum test was used, and for proportions, the χ^2-test was used. Results were considered significant at $P < 0.05$. All statistical computations were carried out using SPSS software (SPSS Inc., Chicago, IL, USA).

Results

Patient sample

Of the 39 patients, 32 were female and 7 were male. The average age of the patients was 72.9 ± 3.3 years in males and 74.9 ± 1.8 years in women (all 74.5 ± 9.8, range 53, 94 years; male 72.9 ± 3.3, range 58, 84 years; female 74.9 ± 1.8, range 53, 94 years; Table 1). All males and 29 women were right-handed. The dominant side was operated in 5 males and 18 women. The final clinical control with conventional radiography was taken after 25.1 ± 11.9 months (male 20.0 ± 2.6 months; female 26.1 ± 2.2 months; Table 1).

Patient's subjective operative satisfaction

The parameters were evaluated according to Constant and Murley [25] and compared with the non-operated side. All three parameters were significantly different only in the female sample compared with the non-operated side (pain 12.8 ± 1.0 vs. 14.2 ± 0.3, activity 8.6 ± 0.3 vs. 9.6 ± 0.3 and position 8.6 ± 0.3 vs. 9.8 ± 0.1; operated vs. healthy; each $P < 0.05$; Table 2). There was no significant difference in the three parameters in the male sample (pain 12.0 ± 1.0 vs. 14.3 ± 0.7, activity 9.1 ± 0.6 vs. 9.7 ± 0.3 and position 8.3 ± 0.9 vs. 10.0 ± 0.0; operated vs. healthy; each $P > 0.05$; Table 2). However, significant difference was found after total evaluation of the parameters as well in the male (30.3 ± 1.4 vs. 34.0 ± 0.7; operated vs. healthy; $P < 0.05$) as in the female (30.0 ± 1.1 vs. 33.7 ± 0.7; operated vs. healthy; $P < 0.05$) sample (Table 2). The subjective functionality in both samples was comparable.

Objective postoperative shoulder functionality

The objective functionality was evaluated according to Constant and Murley [25] and compared with the healthy side (Table 3). Significant differences were found mainly in the female sample compared with the non-operated side (abduction 2.9 ± 0.3 vs. 5.0 ± 0.6, forward flexion 7.2 ± 0.4 vs. 9.4 ± 0.2, elevation 7.2 ± 0.5 vs. 9.5 ± 0.2, external rotation 8.0 ± 0.5 vs. 9.8 ± 0.1, internal rotation 7.3 ± 0.5 vs. 9.0 ± 0.3; operated vs. healthy side; each $P < 0.05$; Table 3). The overall analysis of the Constant–Murley score showed also significant difference in the male sample (male 37.7 ± vs. 50.6 ± 1.7, female 34.4 ± 2.0 vs. 45.2 ± 1.1; operated vs. healthy side; each $P < 0.05$). The overall functionality of the shoulder was in both samples comparable (Table 3).

Table 1 Presented are the demographic data of the operated sample

Characteristics	Total	Male	Female	*P* value
Patients (*N*)	39	7	32	ns†
Dominant side (r/l)	36/3	7/0	29/3	ns†
Operated side (r/l)	22/17	5/2	17/15	ns†
Operated dominant side (*N*)	22	5	18	ns†
Age ad operation (years)	74.5 ± 9.8 (53, 94)	72.9 ± 3.3 (58, 84)	74.9 ± 1.8 (53, 94)	0.621*
Postoperative control (months)	25.1 ± 11.9	20.0 ± 2.6	26.1 ± 2.2	0.221*

32 female and 7 male patients were treated with the Targon®-PH nail. The dominant side was mainly operated in the male as well as in the female group. Data are given as mean ± SEM (range) and the data were considered as significant if $P < 0.05$. * Student's *t* test; † χ^2-test

Table 2 Depicted are subjective parameters of the Constant–Murley score

Arbitrary units	Male	Female	*P* value Op. vs. healthy male/female
Pain Op.	12.8 ± 1.0 (10.4, 15.3)	12.8 ± 0.5 (11.7, 13.9)	0.270/**0.030***
Pain healthy	14.3 ± 0.7 (12.5, 16.0)	14.2 ± 0.3 (13.6, 14.9)	
Activity Op.	9.1 ± 0.6 (7.7, 10.6)	8.6 ± 0.5 (7.6, 9.5)	0.400/0.097*
Activity healthy	9.7 ± 0.3 (9.0, 10.4)	9.6 ± 0.33 (8.9, 10.2)	
Position Op.	8.3 ± 0.9 (6.0, 10.5)	8.6 ± 0.3 (8.0, 9.3)	0.086/**<0.001***
Position healthy	10.0 ± 0.00	9.8 ± 0.1 (9.7, 10.1)	
Total Op.	30.3 ± 1.4 (26.8, 33.8)	30.0 ± 1.1 (27.9, 32.1)	**0.040/0.004***
Total healthy	34.0 ± 0.7 (32.2, 35.8)	33.7 ± 0.7 (32.3, 35.0)	

Significant differences were found mainly in the female sample. However, the overall satisfaction was in both samples comparable with a good reintegration in daily life. Data are given as mean ± SEM (confidence interval 95%) and the data were considered as significant if $P < 0.05$. * One-way ANOVA

Table 3 Shown are the objective parameters of the Constant–Murley score

Arbitrary units	Male	Female	*P* value Op. vs. healthy male/female
Abduction Op.	8.3 ± 3.0 (0.9, 15.7)	2.9 ± 0.3 (2.2, 3.5)	0.468/**0.002***
Abduction healthy	11.3 ± 2.6 (4.9, 17.7)	5.0 ± 0.6 (3.8, 6.2)	
Frw. flexion Op.	7.1 ± 0.9 (5.0, 9.2)	7.2 ± 0.4 (6.3, 8.1)	**0.014/<0.001***
Frw. flexion healthy	9.7 ± 0.3 (9.0, 10.4)	9.4 ± 0.2 (9.1, 9.8)	
Elevation Op.	7.1 ± 0.9 (5.0, 9.2)	7.2 ± 0.5 (6.2, 8.2)	0.056/**<0.001***
Elevation healthy	9.1 ± 0.4 (8.2, 10.1)	9.5 ± 0.2 (9.1, 9.9)	
Ext. rotation Op.	8.0 ± 1.2 (5.2, 10.8)	8.0 ± 0.5 (6.9, 9.1)	0.108/**0.001***
Ext. rotation healthy	10.0 ± 0.00	9.8 ± 0.1 (9.5, 10.1)	
Int. rotation Op.	4.6 ± 1.3 (1.4, 7.7)	7.3 ± 0.5 (6.4, 8.3)	0.234/**0.002***
Int. rotation healthy	6.6 ± 0.9 (4.3, 8.9)	9.0 ± 0.3 (8.5, 9.5)	
Total Op.	37.7 ± 5.4 (24.6, 50.9)	34.5 ± 2.0 (30.4, 38.6)	**0.042/<0.001***
Total healthy	50.6 ± 1.7 (46.3, 54.8)	45.2 ± 1.1 (43.0, 47.4)	

Significant differences were found mainly in the female sample. The overall functionality reached in both groups comparable values with significantly decreased end-functionality of the operated shoulder. Data are given as mean ± SEM (confidence interval 95%), and the data were considered as significant if $P < 0.05$. * One-way ANOVA

Discussion

The presented findings show a good postoperative functional outcome and a good relief from pain according to the severity of the injury. The main advantage of intramedullary rigid fixation is the early painless functionality and social reintegration of the elderly patient. This minimally invasive method provides the advantage of less soft tissue injury and hence less postoperative pain and loss of functionality. Due to early physiotherapy, the complication of a frozen shoulder has not been observed in this study at all. This minimally invasive technique may preserve periostal bridges, representing the last link of perfusion of the adjacent fragments, when performed minimally invasive [26]. This might be the reason why no humeral head necrosis was observed in this patient sample after the final follow-up. The disadvantage of this intramedullary fixation technique is the fixation of the long *M.biceps brachii* tendon by improper positioning of the application device. The mal-rotation of the nail may cause the positioning of the two lateromedial screws into the groove of the long bicipital tendon (Fig. 1a). The closed reposition in three and especially in four-part fractures is a very demanding procedure and often frustrating. Before applying the technique of closed reduction the nature of the fracture has to be understood, the relative position and amount of the different fragments have to be precisely determined. Completely dislocated humeral head fractures cannot be reduced by closed reposition. Therefore, a CT scan with a three-dimensional reconstruction may be very helpful [27]. The axillar nerve is not to be expected to be injured by the osteosynthesis material due to the distant screw position of the implant (Fig. 2).

During the last decade, the popularity of angular-stable implants led to an increased tendency in plating humeral head fractures. As shown earlier, plating and nailing of humeral head fractures seem to give same results [28]. These implants may also prevent bone healing by preventing the contact of the fragments [29]. Further, open reduction and internal fixation of these fractures lead to an iatrogenic devascularization and a higher rate in humeral head necrosis [30]. The use of the Targon®-PH nail seems to remain a domain of geriatric surgery with the hypothetical exception of the fractured calcar size. When the size of the fractured calcar is less than 8 mm (0.31 inch), the risk of the humeral head necrosis is significantly increasing. In dislocated fractures in younger people, the open reduction and internal fixation by conventional plate osteosynthesis render the humeral head to further risk of necrosis by the

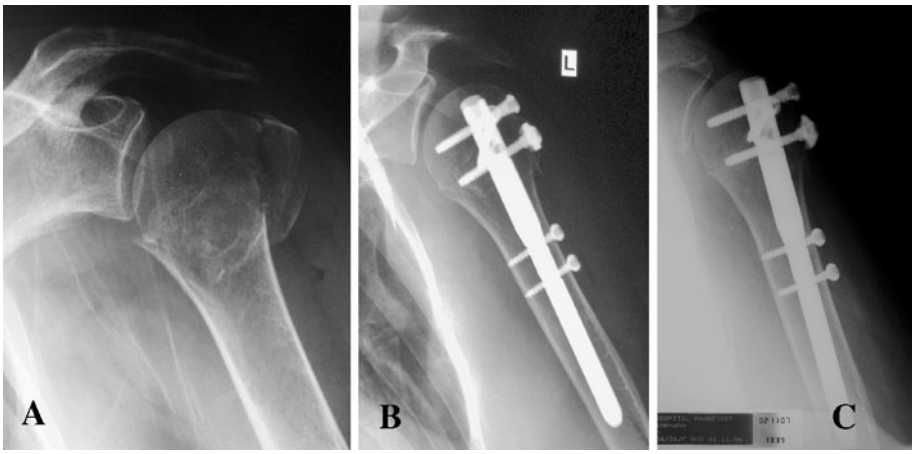

Fig. 2 Radiographic sequence of a two-part humeral head fracture. **a** Conventional X-ray of the shoulder after suffering the accident. **b** Postoperative radiological control shows anatomical reposition. **c** X-ray obtained from the same shoulder 13 months after operative treatment. No necrosis or secondary fragment dislocation was found

destruction of the periostal bridges and to secondary arthroplasty in such cases. Simple fractures in younger patients with severe osteoporosis could be also treated by the Targon®-PH nail, the intramedullary fixation could enhance the stability in osteoporotic bones.

Intramedullary fixation of humeral head fractures gives good results in elderly patients and seems to be a good alternative method to treat this type of fractures. The early painless mobilization and early social integration point on to this minimally invasive method in a selected geriatric population with a pre-existing reduced shoulder motion range.

Conflict of interest No financial support was used for this study. No financial benefits for the authors will result by publication of this study. B-Braun® who produces the Targon®-PH nail supported this study only by offering photographs of the Targon®-PH nail (Fig. 1), no financial support was/will be provided by B-Braun®.

References

1. Court-Brown CM, Caesar B (2006) Epidemiology of adult fractures: a review. Injury 37:691–697
2. Court-Brown CM, Garg A, McQueen MM (2001) The epidemiology of proximal humeral fractures. Acta Orthop Scand 72:365–371
3. Bosch U, Skutek M, Fremerey RW, Tscherne H (1998) Outcome after primary and secondary hemiarthroplasty in elderly patients with fractures of the proximal humerus. J Shoulder Elbow Surg 7:479–484
4. Hintermann B, Trouillier HH, Schafer D (2000) Rigid internal fixation of fractures of the proximal humerus in older patients. J Bone Joint Surg 82-B:1107–1112
5. Kostler W, Strohm PC, Sudkamp NP (2003) Proximal humerus fracture in advanced age: treatment with fixed angle plate osteosynthesis. Chirurg 74:985–989 [German]
6. Koukakis A, Apostolou CD, Taneja T, Korres DS, Amini A (2006) Fixation of proximal humerus fractures using the PHILOS plate: early experience. Clin Orthop 442:115–120
7. Lill H, Josten C (2001) Conservative or operative treatment of numeral head fractures in the elderly? Chirurg 72:1224–1234 [German]
8. Zyto K, Ahrengart L, Sperber A, Tornkvist H (1997) Treatment of displaced proximal humeral fractures in elderly patients. J Bone Joint Surg 79-B:412–417
9. Misra A, Kapur R, Maffulli N (2001) Complex proximal humeral fractures in adults: a systematic review of management. Injury 32:363–372 [Review]
10. Rüter A (2001) Indication and technique for shoulder endoprostheses in fractures. Chirurg 72:1246–1252 [German]
11. Goldman RT, Koval KJ, Cuomo F, Gallagher MA, Zuckerman JD (1995) Functional outcome after humeral head replacement for acute three- and four-part proximal humeral fractures. J Shoulder Elbow Surg 4:81–86
12. Prakash V, McGurty DW, Dent JA (2002) Hemiarthroplasty for severe fractures of the proximal humerus. J Shoulder Elbow Surg 11:428–430
13. Boileau P, Krishnan SG, Tinsi L et al (2002) Tuberosity malposition and migration: reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. J Shoulder Elbow Surg 11:401–412
14. Kralinger F, Schwaiger R, Wambacher M et al (2004) Outcome after primary hemiarthroplasty for fracture of the head of the humerus: a retrospective multicentre study of 167 patients. J Bone Joint Surg 86-B:217–219
15. Murray IR, Amin AK, White TO, Robinson CM (2011) Proximal humeral fractures: current concepts in classification, treatment and outcomes. J Bone Joint Surg 93:1–11 [Review]
16. Hertel R, Hempfing A, Stiehler M, Leunig M (2004) Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J Shoulder Elbow Surg 13:427–433
17. Plecko M, Kraus A (2005) Internal fixation of proximal humerus fractures using the locking proximal humerus plate. Oper Orthop Traumatol 17:25–50
18. Resch H, Povacz P, Frohlich R, Wambacher M (1997) Percutaneous fixation of threeand four-part fractures of the proximal humerus. J Bone Joint Surg 79-B:295–300
19. Cuny C, Scarlat MM, Irrazi M, Beau P, Wenger V et al (2008) The Telegraph nail for proximal humeral fractures: a prospective four-year study. J Shoulder Elbow Surg 17:539–545
20. Linhart W, Ueblacker P, Grossterlinden L, Kschowak P, Briem D et al (2007) Antegrade nailing of humeral head fractures with captured interlocking screws. J Orthop Trauma 21:285–294
21. Lill H, Hepp P, Korner J et al (2003) Proximal humeral fractures: how stiff should an implant be? A comparative mechanical study with new implants in human specimens. Arch Orthop Trauma Surg 123:74–81
22. Böhler Lorenz (1951) Die Techniken der Knochenbruchbehandlung, 13th edn. Ausg., Maudrich, Wien

23. Neer CS 2nd (1970) Displaced proximal humeral fractures. I. Classification and evaluation. J Bone Joint Surg Am 52:1077–1089
24. Mathews J, Lobenhoffer P (2007) The Targon PH nail as an internal fixator for unstable fractures of the proximal humerus. Oper Orthop Traumatol 19:255–275
25. Constant CR, Murley AHG (1986) A clinical method of functional assessment of the shoulder. J Bone Joint Surg 68-B:667
26. Gerber C, Hersche O, Berberat C (1998) The clinical relevance of posttraumatic avascular necrosis of the humeral head. J Shoulder Elbow Surg 7:586–590
27. Resch H, Hubner C, Schwaiger R (2001) Minimally invasive reduction and osteosynthesis of articular fractures of the humeral head. Injury 32(Suppl 1):25–32
28. Gradl G, Dietze A, Kääb M, Hopfenmüller W, Mittlmeier T (2009) Is locking nailing of humeral head fractures superior to locking plate fixation? Clin Orthop Relat Res 467:2986–2993
29. Sadowski C, Riand N, Stern R, Hoffmeyer P (2003) Fixation of fractures of the proximal humerus with the PlantTan Humerus Fixator Plate: early experience with a new implant. J Shoulder Elbow Surg 12:148–151
30. Savoie FH, Geissler WB, Vandergriend RA (1989) Open reduction and internal fixation of three-part fractures of the proximal humerus. Orthopedics 12:65–70